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HOW TO DETERMINE POLYETHYLENE GLYCOL 1,000 CONTENT IN TREATED WOOD

Howard N. Rosen, *Research Chemical Engineer*
Forestry Sciences Laboratory
Carbondale, Illinois

ABSTRACT.--An experimental technique using water extraction for evaluation of the content of polyethylene glycol of molecular weight 1,000 in wood where the ovendry weight of the untreated wood is not available was shown to be applicable for PEG-treated black oak and yellow-poplar.

OXFORD: 842.2. KEY WORDS: extraction, resin, *Liriodendron tulipifera*, *Quercus velutina*.

Polyethylene glycol of molecular weight 1000 (PEG) is used to improve the dimensional stability of wood (Mitchell 1972, Stamm 1959). Its content and distribution in treated wood is of interest so that the effectiveness of treatments can be evaluated. If the ovendry weight of the wood before treatment is not known, PEG content can be determined using either water extraction (Moore and Johnson 1967) or a gravimetric or colorimetric method based on PEG reaction to the heteropoly silicotungstic and phosphomolybdic acids (Shaffer and Critchfield 1947). However, the presence of water solubles in the wood confound the PEG analysis by extraction. The object of this note is to demonstrate how the PEG content of wood, even with significant water solubles, can be evaluated when the ovendry weight of the wood before treatment is not known.

TECHNIQUES

The samples consisted of 18 wafers each of yellow-poplar (*Liriodendron tulipifera* L.) sapwood and black oak (*Quercus velutina* L.) heartwood, 2.5 by 2.5 by 0.4 cm along the grain. These were ovendried and weighed: their weights ranged from approximately 1 to 2 gm.

Twelve wafers of each species were treated with a 50 percent aqueous PEG solution using a full cell method. The samples were ovendried again, reweighed, and the percent PEG calculated by direct weight (table 1).

The extraction method used was similar to one described by Browning (1957). Each wafer was first cut into shavings which were ovendried for 4 hours at 102° C. Ovendry weights were made in airtight weighing bottles, after which the shavings were transferred to cellulose extraction thimbles. The thimbles were placed in a Soxhlet extractor (85 ml capacity equipped with an Allihn condensor) and attached to a 500 ml flask half filled with distilled water. The shavings were extracted for 16 hours.

The shavings then were ovendried for 4 hours while still in the thimble after which they were transferred to weighing bottles.

Table 1.--*Comparison of PEG content by direct weight and water extraction methods*

(In percent)

Wafer No.	Yellow-poplar[1]		Wafer No.	Black oak[2]	
	Direct weight	Extraction		Direct weight	Extraction
1	83.9	82.9	13	18.0	17.1
2	78.6	80.3	14	19.8	20.6
3	75.3	75.2	15	21.2	21.6
4	74.8	76.4	16	20.2	21.3
5	83.1	81.8	17	19.0	18.4
6	76.0	75.2	18	21.4	21.6
7	78.6	77.9	19	18.6	17.3
8	74.0	74.8	20	24.7	25.1
9	81.4	78.7	21	24.6	23.6
10	82.1	81.0	22	23.1	21.4
11	81.7	79.8	23	23.6	21.8
12	83.0	82.1	24	22.0	20.6

[1] Water solubles content of 2.8 percent based on six replicates.

[2] Water solubles content of 4.8 percent based on six replicates.

The water remaining in the flask and Soxhlet extractor was poured into evaporating dishes (50 ml disposable aluminum dishes are convenient), evaporated to dryness at 80° C or less to avoid splattering, and dried for 1 hour at 102° C before obtaining the weight of extract.

The extract of the PEG-treated samples was comprised of PEG as well as water solubles. Therefore, the remaining untreated wafers of each specie were extracted in the same way as the treated wafers to determine a correction for the water solubles.

The percent water solubles (percent S) was calculated by two methods: (1) by dividing the weight of the solubles by the initial weight of the wood multiplied by 100 and (2) by dividing the difference between the initial and extracted weight of the wood by the initial weight of the wood multiplied by 100. Ideally, the two results should have been the same for the same sample, but experimental error caused some differences. We averaged the two values to determine percent S. However, the differences were so small that we could have used either value just so we were consistent in using method 1 or method 2.

A treated dowel (yellow-poplar 3.6 cm in diameter and 5.0 cm along the grain weighing approximately 26 gm) was used to show how percent PEG can be determined on samples too large to fit in one Soxhlet extractor.

The dowel was cut into eight sections and separate percent PEG determinations were made on each section. The percent PEG for the entire sample was based on a weight average for the eight sections; sum of the weights times percent PEG divided by the sum of the weights of the sections.

The percent PEG (weight of PEG per unit weight of dry wood with water solubles multiplied by 100) can be calculated using either of the following equations:

$$\text{Percent PEG} = \frac{100(W - W_o) - (\text{percent S})(W)}{W_o} \quad (1)$$

$$\text{Percent PEG} = \frac{100\ W_e - (\text{percent S})(W)}{W - W_e} \quad (2)$$

Where W is the ovendry weight of treated wood, W_o is the ovendry weight of extracted wood, and W_e is the ovendry weight of all extract (water solubles and PEG).

Theoretically, equations 1 and 2 should give equal results of percent PEG because $W = W_o + W_e$, but experimental error will cause slight differences in the values. The percent PEG was calculated by averaging the results of both equations. Good experimental technique should give percent PEG values by equations 1 and 2 within 1 percent of each other.

RESULTS AND DISCUSSION

The PEG concentrations determined using the water extractive method compared favorably to those derived by the direct weight method (table 1). The difference in the means was not significant at the 10 percent level for either yellow-poplar or black oak. A PEG content of 83.8 percent by direct weight compared favorably to 81.4 percent by extraction for the dowel. Equations 1 and 2 gave a percent PEG difference of less than 1 percent in 27 of the 32 extractions.

Although determination of PEG by direct weight is easier to evaluate than by water extraction, the direct weight method is not practical because PEG is usually incorporated into green wood; thus, the ovendry weight of the wood is not known. The water extraction method is also useful in determining PEG distributions by selectively

sectioning the whole sample and determining PEG contents of the individual sections.

Moore and Johnson (1967) suggest that PEG-treated wood should be ovendried under vacuum at 67° C rather than 100° C at atmospheric pressure to eliminate weight losses in the sample due to chemical decomposition on continued heating at 100° C. In this study, dry wood shavings with 80 percent PEG content and dry pure PEG mixed with 5 percent wood extractives subjected to 102° C for 1 week resulted in weight differences of less than 0.2 percent. Therefore, I do not believe that ovendrying of PEG-treated wood at 102° C for 4 hours will cause significant chemical decomposition.

The extractive technique was used for PEG of molecular weight 1,000 in this study, but the method might be appropriate for PEG of other molecular weights as well as many water soluble chemicals.

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